

THUNDER BAY BEACHES, 1985

April, 1986



Ontario

Ministry
of the
Environment

W.M. VROOMAN, Director
Northwestern Region

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THUNDER BAY BEACHES, 1985

Factors Affecting the Bacteriological
Water Quality of Selected Beaches
In the Thunder Bay Area

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SUMMARY

A bacteriological study of the factors affecting the water quality of selected bathing areas in the Thunder Bay area, initiated in 1984, was continued during the summer of 1985. Five beaches and associated off-beach pollution sources were monitored: Chippewa Beach, Lakeview Beach, Sandy Cove Beach, Sunnyside Beach, and Hazelwood Beach.

At Chippewa Beach, the fecal coliform (FC) geometric mean of the nine bathing area stations exceeded 100 FC per 100 ml on half of the days on which the MOE collected water samples. The bacteriological water quality of the bathing area was extremely sensitive to any factor that stirred up the sediments underlying the bathing area or introduced material from the sand beach into the water of the bathing area. This included stormwater run-off, high waves and grading of the beach. It appeared that the beach sand and the shallow water was contaminated with droppings from ducks and gulls or other birds and animals. Abatement of this problem will be difficult and the intermittent bacteriological contamination of the bathing area is expected to continue.

At Boulevard Lake Park, the three beaches on Boulevard Lake all reacted in a similar fashion to the effects of heavy rainfall. The daily fecal coliform geometric mean of 100 FC per 100 ml was exceeded on four days at Lakeview Beach, two days at Sandy Cove Beach and three days at Sunnyside Beach. The fecal bacterial contamination of the bathing area persisted longer at Lakeview Beach than the other two beaches.

The bacteriological water quality of the bathing area at Hazelwood Beach was excellent throughout the summer. The reduced number of bathers at this beach in 1985 may have helped to contribute to this condition.

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INTRODUCTION

In 1984, a study was undertaken by the Ministry of the Environment to determine the various factors affecting the bacteriological water quality of selected bathing areas in or near the City of Thunder Bay. The results of this study were reported in "Thunder Bay Beaches, 1984" (1). The 1985 study was a continuation of the 1984 work. It examined specific areas in which the data collected in 1984 were either inconclusive or new factors had been introduced.

In 1985, the following aspects were examined in detail:

1. A detailed monitoring of the water quality of the outfalls flowing into Boulevard Lake following heavy rains.
2. A comprehensive study of the extent and duration of the bacterial contamination of the bathing area at Chippewa Beach following heavy rains.
3. The effect of the presence of day-camp bather activities on the water quality of the bathing area at Chippewa Beach.
4. The effect of the reduced bather activities on the water quality of the bathing area at Hazelwood Lake Beach.

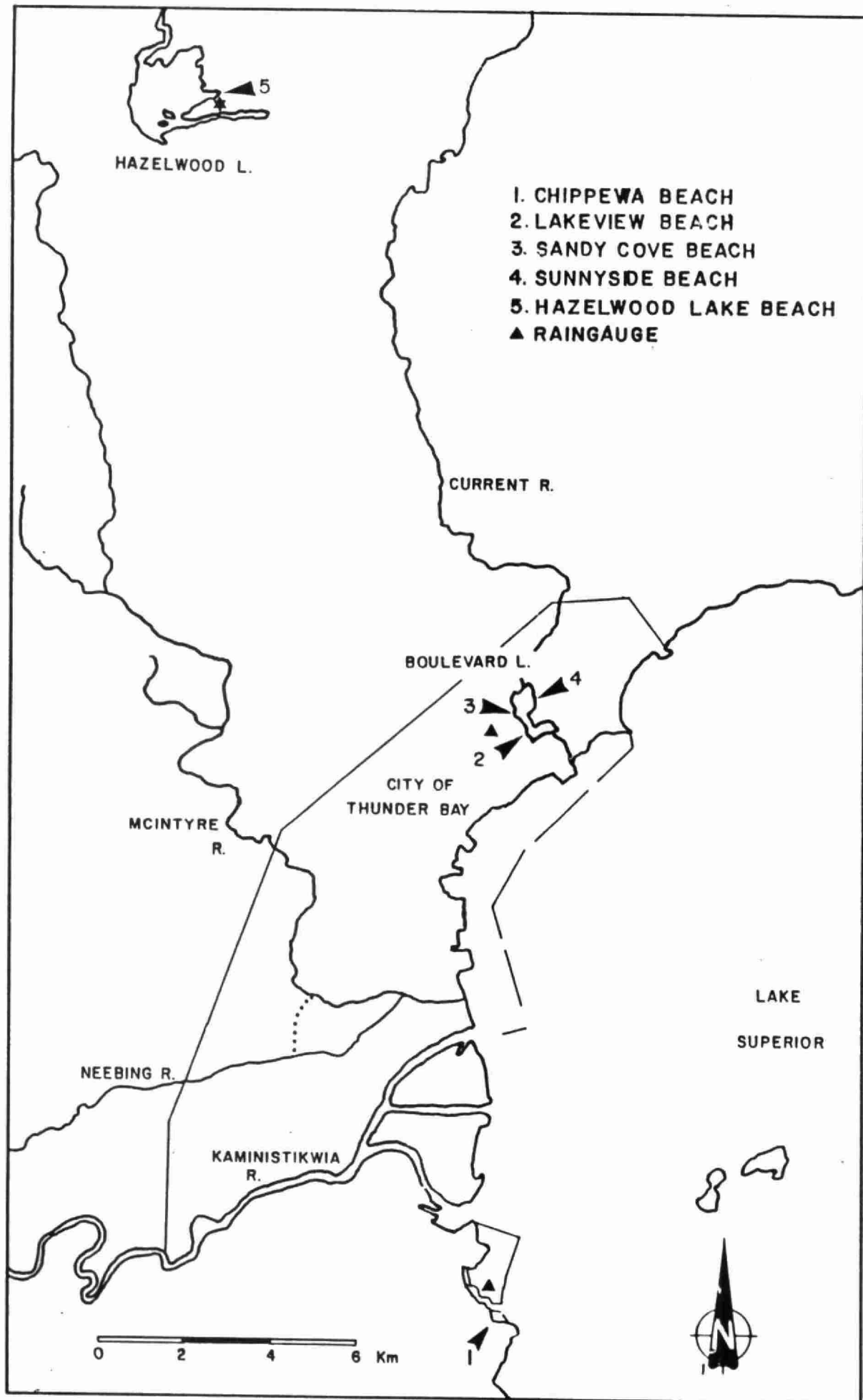


Figure 1. Location of beaches and rain gauges in the 1985 Thunder Bay Beaches Study.

GENERAL METHODS

Five beaches and associated off-beach pollution sources were monitored in the 1985 Thunder Bay Beaches Study: Chippewa Beach, Chippewa Park; Lakeview Beach, Sandy Cove Beach, and Sunnyside Beach, Boulevard Lake Park; and Hazelwood Beach, Hazelwood Lake Conservation Area (Figure 1). The field and laboratory methods used in the 1985 study were generally the same as those outlined in the 1984 report (1). However, in 1985, several modifications were made to both the locations of the sampling stations and the sampling frequency at specific beaches. These changes were necessary to provide detailed information on the influence of bather loading and the sources and persistence of the bacterial contamination in the bathing area.

In 1984, samples from both the bathing area and off-beach pollution sources were collected by Ministry of Environment (MOE) staff and analyzed at the MOE Laboratory in Thunder Bay. In that study, the bathing area samples served two purposes: to determine the suitability of the water quality for bathing, and to determine the potential sources of bacterial contaminants entering the bathing area. All bacteriological results were reported to the Thunder Bay District Medical Officer of Health (MOH).

In 1985, samples from both the bathing area and the off-beach pollution sources were again collected by MOE staff. However, the MOE bathing area samples were collected only for the purpose of determining the impact of various factors upon the water quality of the bathing area, not the suitability for bathing. The suitability of the water for bathing was assessed by the MOH using samples collected by staff from the Thunder Bay District Health Unit (TBDHU). These samples were analyzed at the Thunder Bay Public Health Laboratory.

In 1985, MOE water sample collection was initiated in the second week of July and continued until the third week of August. All samples were collected on weekdays. No samples were collected on weekends or holidays due to the lack of immediate analytical support on those days. Samples were analyzed within 3 hours of collection at the Ministry of Environment Laboratory, Thunder Bay.

During the first week of the study, the following bacterial groups were analyzed: total coliform (TC), fecal coliform (FC), fecal streptococcus (FS), Pseudomonas aeruginosa (PSA), and Escherichia coli (EC). However, once the levels of these parameters had been established, only FC, EC, and PSA were analyzed routinely.

Whenever the calculation of geometric means included 'less than' bacteriological data, the value used was equal to one half of the absolute value of the 'less than' figure. This was based not only upon the observation that the bacteriological data for these beaches were often at or near this level when larger sample aliquots were analyzed, but also the necessity to have real numbers for the geometric mean calculation, and the negligible impact that this modification would have on the data set. Similarly, when the geometric mean calculation included bacteriological data that were beyond the upper counting range ('greater than' data), the absolute value of the 'greater than' data was used. This practice reduced the extent to which the bacterial levels may have fluctuated. In fact, the actual levels may have been much higher had a more suitable aliquot of sample been analyzed. Nevertheless, this was the best alternative available after it was observed that counts of excessively crowded FC membranes gave greatly inflated values for these beaches due to the lack of differentiation between target and non-target colonies.

As in 1984, the responsibility for beach placarding rested solely with the Thunder Bay District Medical Officer of Health. The Ministry of Health fecal coliform water quality guideline used in 1985 was identical to that used in 1984. This guideline is stated below:

" The quality of bathing beach waters is considered impaired when the... fecal coliform geometric mean exceeds 100 per 100 ml" (2)

RESULTS AND DISCUSSION

1. CHIPPEWA PARK

BACKGROUND

Between May and August, 1984, the fecal coliform daily geometric means of samples collected from the bathing area at Chippewa Beach were found to exceed 100 per 100 ml on eleven days. The bathing area was placarded twice during the summer of 1984. The primary cause of the fecal contamination in the bathing area at Chippewa Beach was stormwater run-off entering the bathing area following heavy rains. The principal sources of this stormwater appeared to be two outfalls - water from a ditch that flowed directly into the bathing area and a second, intermittent outfall, whose exact source was not determined.

In 1985, the Chippewa Day Camp returned to Chippewa Park again. In the summer of 1984, due to the lack of maintenance at Chippewa Park because of a strike by City of Thunder Bay outside workers, the day-camp was moved to Hazelwood Lake Conservation Area. At Hazelwood Beach, the bathing activities of the day-camp children had caused the water quality in the bathing area to deteriorate. It was uncertain whether or not this same effect would be observed at Chippewa Beach in 1985. Therefore, the effects of bather loading was studied in some detail at this beach during the summer of 1985.

METHODS

Sampling Stations: In 1985, the day-camp staff had cordoned off a small section of the bathing area at Chippewa Beach with buoys (Figure 2). This supervised area was used by the children attending the day-camp for all bathing activities.

The number of beach stations was increased in 1985 from that used in 1984 to more effectively monitor the contribution of the day-camp bathers. Nine beach stations were used to monitor the water quality of the bathing area at Chippewa Beach in 1985.

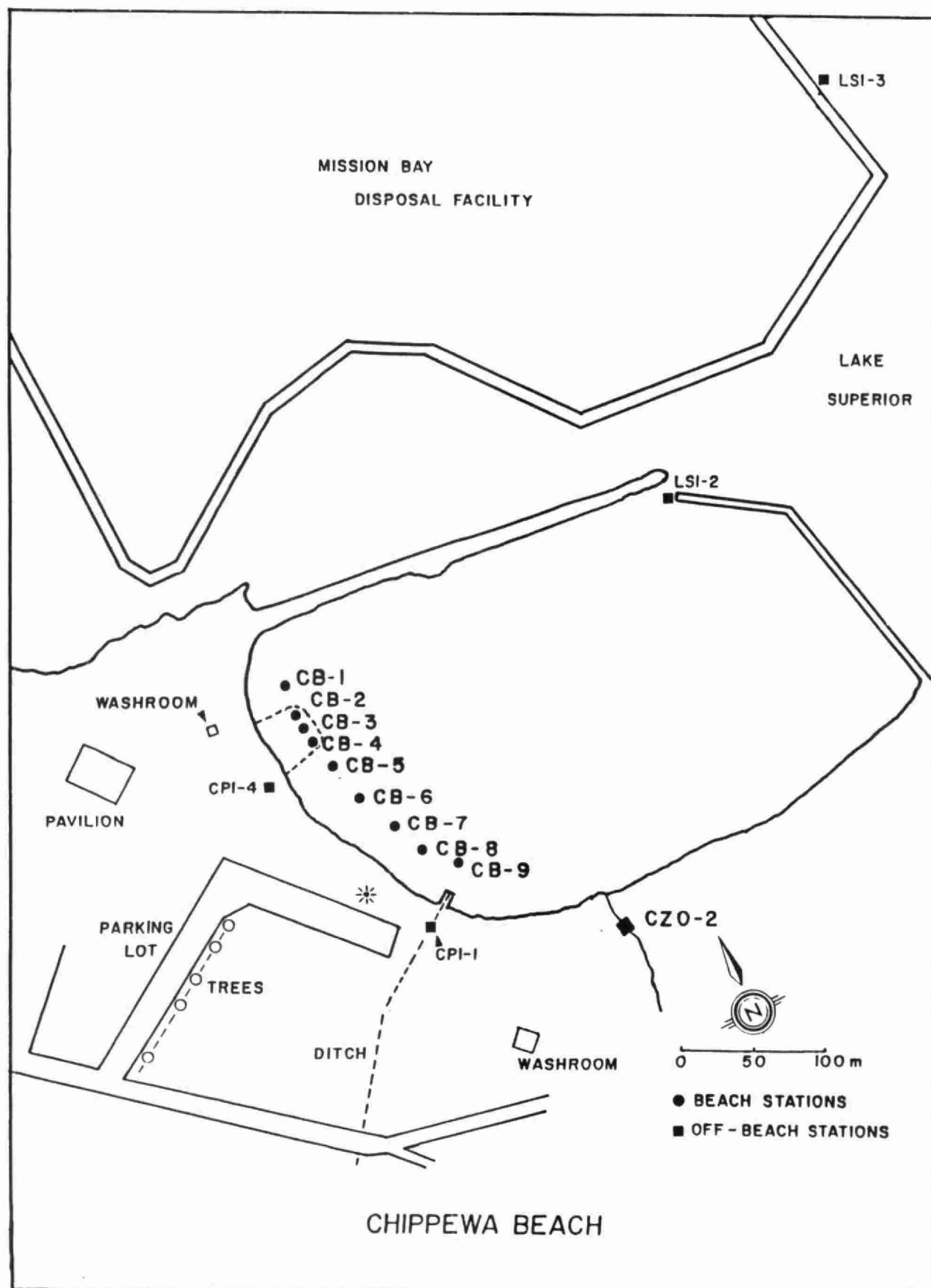


Figure 2. Location of beach and off-beach sampling stations at Chippewa Beach, Chippewa Park.

Three beach stations, CB-2, 3, and 4, were established inside the buoy lines of the day-camp bathing area (Figure 2). The other beach stations were spread evenly across the area set aside for public bathing. Station CB-1 was outside the buoys, to the left of the day-camp bathing area and stations CB-5, 6, 7, 8, 9, were to the right. Beach stations were each located approximately the same distance from shore, in water of similar depth. In 1985, the beach stations CB-2, CB-5, and CB-8 were located in identical positions to the 1984 stations CB-1, CB-2 and CB-3.

A number of the off-beach stations used in 1984 were again employed for the 1985 study. In addition, one new off-beach station, CZ0-2, was established. This station was located to the right of the bathing area, in a small stream that crossed under the sand beach through a culvert. In 1984, the outfall from this culvert was below the surface of the water in the lagoon and was overlooked. This stream drained a small swampy area, a parking lot and the Chippewa Zoo compound via a newly installed culvert upstream.

Sampling Frequency: Beach stations were sampled twice each weekday, once in the morning (between 8:00 and 10:30 a.m.) prior to any bathing activity, and once in the afternoon (between 2:30 and 3:30 p.m.) during or after bathing. However, when bathers were absent during the afternoon, only stations CB-1, 3, 5, 7, and 9, were sampled. With the exception of CPI-1, off-beach stations were usually sampled only in the morning each weekday. CPI-1 was sampled twice each weekday.

Rainfall Monitoring: As in 1984, a rainfall collector was set up at Chippewa Park. The quantity of rain collected was checked both morning and afternoon, just prior to each sampling run. However, only the morning measurements, showing the quantity of rainfall collected in the previous 24 hours are shown in the figures. No rainfall measurements were made on weekends or holidays. Thus, whenever an on-site rainfall measurement was not available, the rainfall recorded at the Thunder Bay airport by Environment Canada was used.

RESULTS AND DISCUSSION

Water sampling at Chippewa Beach was initiated on the afternoon of July 8, 1985, and continued until the afternoon of August 23, 1985. Over this period, Chippewa Beach stations CB-1 to CB-9 were sampled on 34 separate days. Sixty-five individual sampling runs were made. No significant differences in the bacteriological data were found between these stations.

During this period, the daily fecal coliform geometric mean for the nine beach stations exceeded 100 FC per 100 ml on 17 of the 34 days on which beach samples were collected (Table 1). Geometric mean fecal coliform levels that exceeded 100 FC per 100 ml were found in the bathing area on 25 separate sampling runs (underlined values in Table 1). This number appeared unusually high, since a sewage source impacting the bathing area could not be demonstrated at Chippewa Beach.

The twenty-five occasions on which elevated fecal coliform levels were found were grouped into eleven separate fecal coliform 'peaks'. These peaks are shown in Figures 3 and 4. Each peak has a number above it so that individual peaks can be identified more easily. The various physical conditions associated with each peak are listed in Table 2.

TABLE 2. Fecal coliform 'peaks' at Chippewa Beach and associated physical conditions.

PEAK	SAMPLING PERIOD	ASSOCIATED PHYSICAL CONDITIONS
1	July 8,pm	Heavy rainfall
2	July 17,pm to 19,am	Beach grading, heavy rainfall
3	July 24,pm	Heavy rainfall
4	July 25,pm	Beach grading
5	July 30, pm	Beach grading
6	July 31, pm	Unknown
7	August 6,am to 7,pm	Heavy rainfall
8	August 8,pm to 9,pm	Beach Grading
9	August 12,am to 14,pm	Heavy rainfall, high waves
10	August 19,am	Heavy rainfall
11	August 23,am	High waves

Stormwater Run-off: In 1985, as in 1984, it was found that there was a direct relationship between the onset of heavy rainfall that produced stormwater run-off and the immediate appearance of elevated FC levels in the water of the bathing area. During the period of this study, a rainfall greater than 10 mm within the previous 24 hours occurred six times at Chippewa Beach (Figure 3 and 4). Following each of these events, the FC levels in the bathing area exceeded a geometric mean of 100 FC per 100 ml for a period of 24 to 48 hours (peak #1,2,3,7,9,10). Rainfall less than 10 mm did not cause the FC levels in the bathing area to exceed this level.

In the 1984 report (1), the outfalls at CPI-1 and CPI-4 were indicated as the principal sources of the fecal bacteria entering the bathing area at Chippewa Beach. However, in 1985, several factors appeared to mitigate against these outfalls as major contributors to the overall bacterial contamination in the bathing area. The water flowing in the ditch at CPI-1 usually contained elevated levels of FC following heavy rains. However, on several occasions following heavy rains, particularly in August 1985, the levels of FC were unusually low. These low FC levels, when combined with the relatively small volume of water flowing from the ditch, even after heavy rains, did not appear great enough to influence the water quality of the entire lagoon. In fact, FC levels were often highest at beach stations some distance from this outfall. In addition, in 1985, water was observed to flow at CPI-4 on only two occasions. Since there was virtually no flow of water from this outfall at other times, CPI-4 was obviously not a primary source of the fecal bacterial contamination of the bathing area at Chippewa Beach in 1985.

In the same fashion, although the water quality of the outfall at CZO-2 varied like that of CPI-1 in response to heavy rain, this outfall was located even further from the bathing area than CPI-1, and hence, would be expected to influence the water quality of the bathing area even less. Therefore, it appeared that the primary source of the stormwater and fecal bacteria observed in the bathing area at Chippewa Beach, was not from these outfalls but must be from other sources.

TABLE 1. FECAL COLIFORM GEOMETRIC MEAN LEVELS IN THE BATHING AREA AT CHIPPEWA BEACH,
JULY 8 TO AUGUST 23, 1985

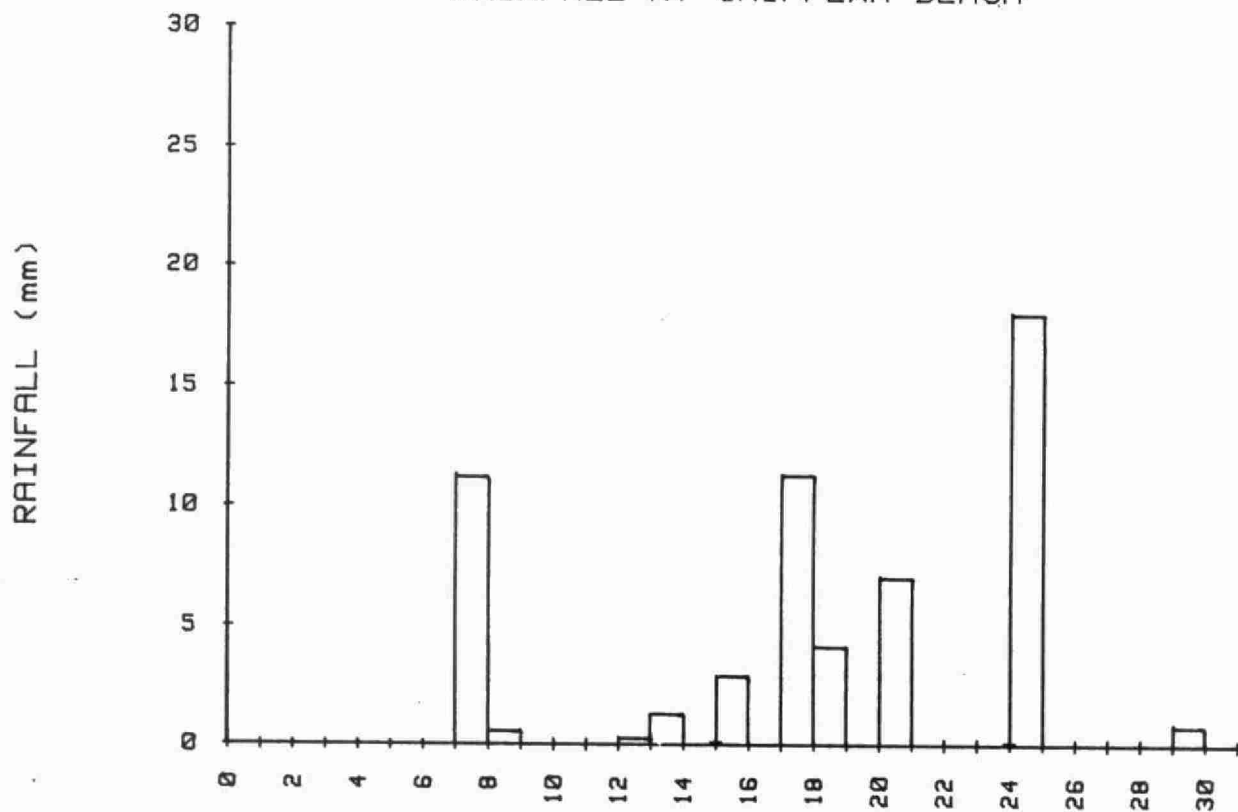
SAMPLING				FECAL COLIFORM COUNTS PER 100 ML										DAILY GEOM. MEAN
DATE			TIME	BEACH STATION NUMBERS										
YY	MM	DD		CB1	CB2	CB3	CB4	CB5	CB6	CB7	CB8	CB9		
85	7	8	8:00											
85	7	8	2:15		120	200		160	120			40	113.0	
85	7	9	8:50	40 <	10	70	<	10	20	20			17.4	
85	7	9	2:55	20	60	100 <	10	50 <	10	40	20		24.3	
85	7	10	8:55	10	10 <	10	10	40 <	10 <	10	10	10	9.3	
85	7	10	3:00	30 <	10	30	20	10	30	40	30	10	19.0	
85	7	11	8:53	<	10	10	30	20	10	20	40	30	20	17.4
85	7	11	2:45	<	10	10 <	10	10	50	40	90	20	16.5	
85	7	12	8:50	20 <	10 <	10	20	20	10 <	10	60	90	15.6	
85	7	12	3:00	<	10 <	10 <	10 <	10 <	10 <	10 <	10 <	10	5.4	
85	7	13	8:00											
85	7	14	8:00											
85	7	15	8:45	10	10	10	20	10 <	10	30	10	10	11.3	
85	7	15	3:00	40	10 <	10	10	10 <	10	10 <	10	40	10.8	
85	7	16	8:55	32		40		36		28			33.7	
85	7	16	3:00	20		10	<	10		10			10.0	
85	7	17	9:00	50		20		40		10			25.1	
85	7	17	3:00	770		670		680		900			749.6	
85	7	18	8:55	540	330	750	800	740	1000	700	520	490	622.9	
85	7	18	3:00	600	540	600	620	660	530	570	330	600	552.0	
85	7	19	9:00	80	140	90	220	160	230	110	220	90	137.7	
85	7	19	3:05	50	90	40	60	110	130	130	80	70	78.4	
85	7	20	8:00											
85	7	21	8:00											
85	7	22	8:45	20 <	10	10	10	50	30	50	120	20	23.0	
85	7	22	2:45	20	40		40 <	10	<	10		20	15.9	
85	7	23	9:00	70	30 <	10	40	20	90	80	40	60	37.5	
85	7	23	2:30	110	110		40 <	10		20		40	35.3	
85	7	24	9:15	200	260	150	160	80	90	150	20	20	93.4	
85	7	24	3:10	890	630		2000	1190		410		90	605.4	
85	7	25	9:30	40	80	100	90	60	130	140	150	180	98.2	
85	7	25	3:00	560	630		370	170		50		130	229.0	
85	7	26	9:15	100	70	90	60	50	80	30	60	30	58.6	
85	7	26	2:45	20	20		10 <	10	<	10		40	12.6	
85	7	27	8:00											
85	7	28	8:00											
85	7	29	9:25	10 <	10	50	10	40	10	10	20	50	16.7	
85	7	29	2:30	44	48		52	40		24		28	37.9	
85	7	30	9:00	20	4	12	20	16	1600	68	12	28	28.2	
85	7	30	3:00	1200	1200		1200	800		800		800	979.8	
85	7	31	9:45	25	28	32	28	80	84	116	104	84	54.5	
85	7	31	3:00	128	200	600	800	44	48	60	40	36	109.4	
85	8	1	9:15	80	76	72	80	72	80	40	28	40	59.3	
85	8	1	3:00	108	56	152	172	56	80	56	16	8	55.6	
85	8	2	8:55	24	20	32	88	300	168	52	40	32	54.9	
85	8	2	3:05	190		120		70		10			63.2	

TABLE 1. FECAL COLIFORM GEOMETRIC MEAN LEVELS IN THE BATHING AREA AT CHIPPEWA BEACH,
JULY 8 TO AUGUST 23, 1985 (continued) ALL DATA

SAMPLING				FECAL COLIFORM COUNTS PER 100 ML								DAILY GEOM. MEAN	
DATE			TIME	BEACH STATION NUMBERS									
YY	MM	DD		CB1	CB2	CB3	CB4	CB5	CB6	CB7	CB8		CB9
85	8	3	8:00										
85	8	4	8:00										
85	8	5	8:00										
85	8	6	9:15					5100	4600	4100	4700	4200	4525.6
85	8	6	3:00	770	660	970	1490	1670	1800	1860	1300	1550	1264.6
85	8	7	9:00	120	190	120	160	200	180	220	250	400	191.5
85	8	7	3:00	40	220	200	290	310	390	270	140	130	188.7
85	8	8	9:00	90	100	130	100	110	30	90	90	80	85.7
85	8	8	3:00	1300	1400	1170	1150	1300	700	530	550	500	882.6
85	8	9	8:00	510	480	440	470	290	330	230	150	110	297.7
85	8	9	3:00	390	230	350	560	150					304.9
85	8	10	8:00										
85	8	11	8:00										
85	8	12	9:00	360	200	180	200	630	850	800	1500	900	485.5
85	8	12	3:00	1500		1500		1500		1500		1500	1500.0
85	8	13	9:00	4000	3600	3300	2500	2700	3100	1800	1900	800	2407.9
85	8	13	3:00	1800	3100	2600	2200	1500		600		400	1417.4
85	8	14	9:00	750	900	650	440	190	180	200	100	170	304.4
85	8	14	3:00	420		440		550		180		90	277.5
85	8	15	9:00	70	110	100	50	90	50	140	70	30	71.8
85	8	15	3:00	10	20	20	30	50		20		20	21.9
85	8	16	9:00										
85	8	16	3:00										
85	8	17	8:00										
85	8	18	8:00										
85	8	19	9:10	150	90	130	150	120	100	110	120	180	125.1
85	8	19	3:00	110		130		50		110		110	97.1
85	8	20	9:00	50	50	60	20	80	70	70	40	70	53.0
85	8	20	3:00	160		100		100		30		90	84.5
85	8	21	9:00	60	50	90	110	80	70	90	10	40	56.6
85	8	21	3:00	240		430		90		10		50	85.8
85	8	22	9:00	30	60	50	60	140	80	60	20	20	48.4
85	8	22	3:00	120		220		100		30		20	69.2
85	8	23	9:00	30	600	3000	340	100	110	30	100	40	142.5
85	8	23	3:00	2000		2000		2000		200		80	662.9
GEOM. MEAN				92.5	76.0	101.3	93.6	93.7	93.3	74.9	73.6	74.4	

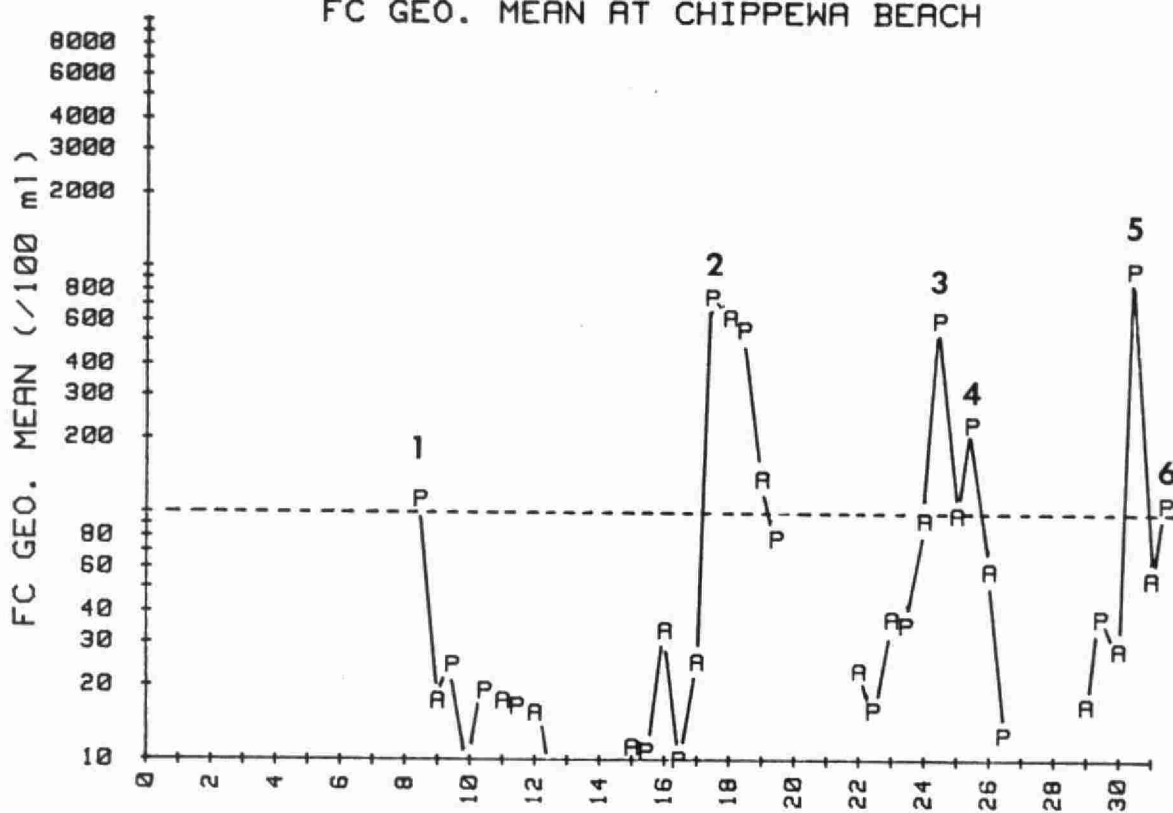
SEASONAL GEOMETRIC MEAN: 85.56

12
RAINFALL AT CHIPPEWA BEACH



JULY 1985

FC GEO. MEAN AT CHIPPEWA BEACH



JULY 1985

Figure 3. Rainfall and morning (A) and afternoon (P) fecal coliform geometric mean levels at Chippewa Beach, July 8 - 31, 1985.

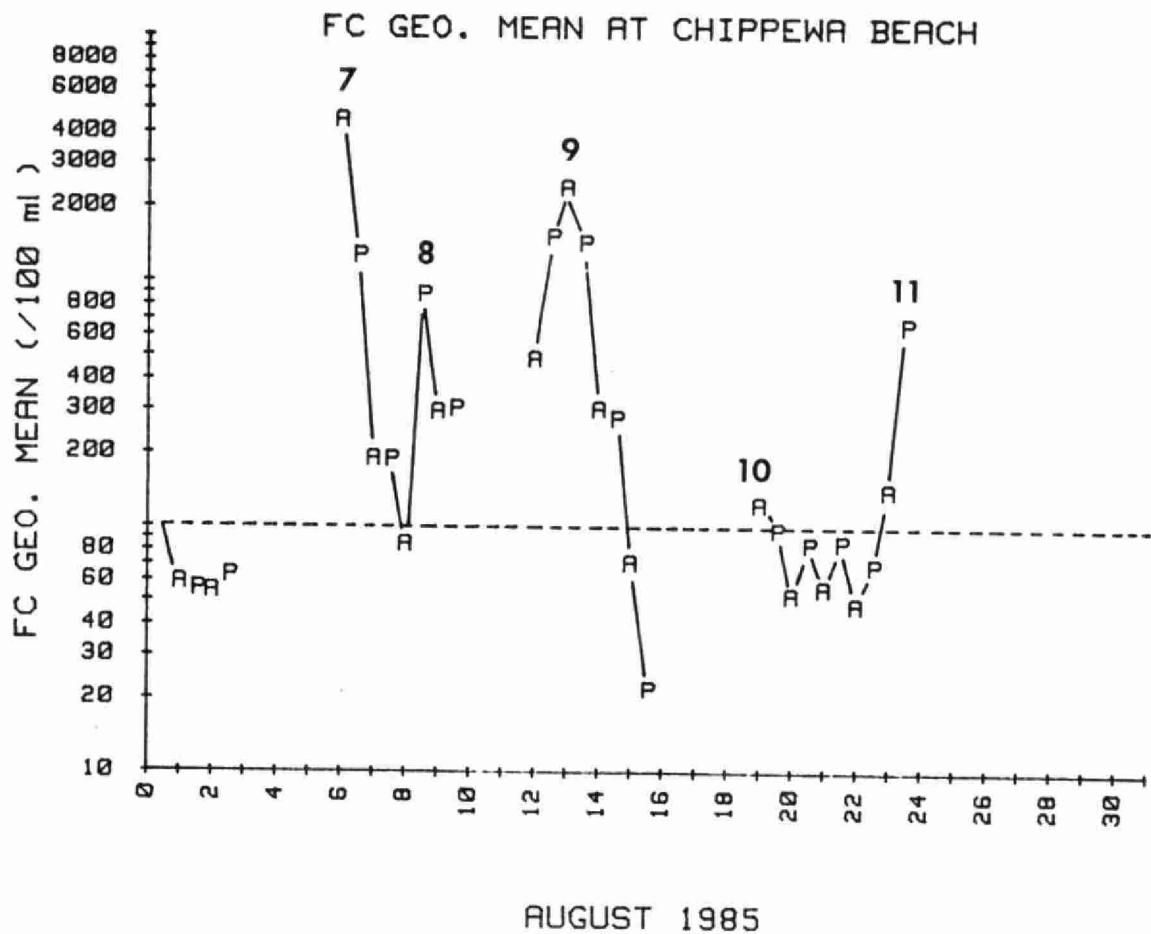
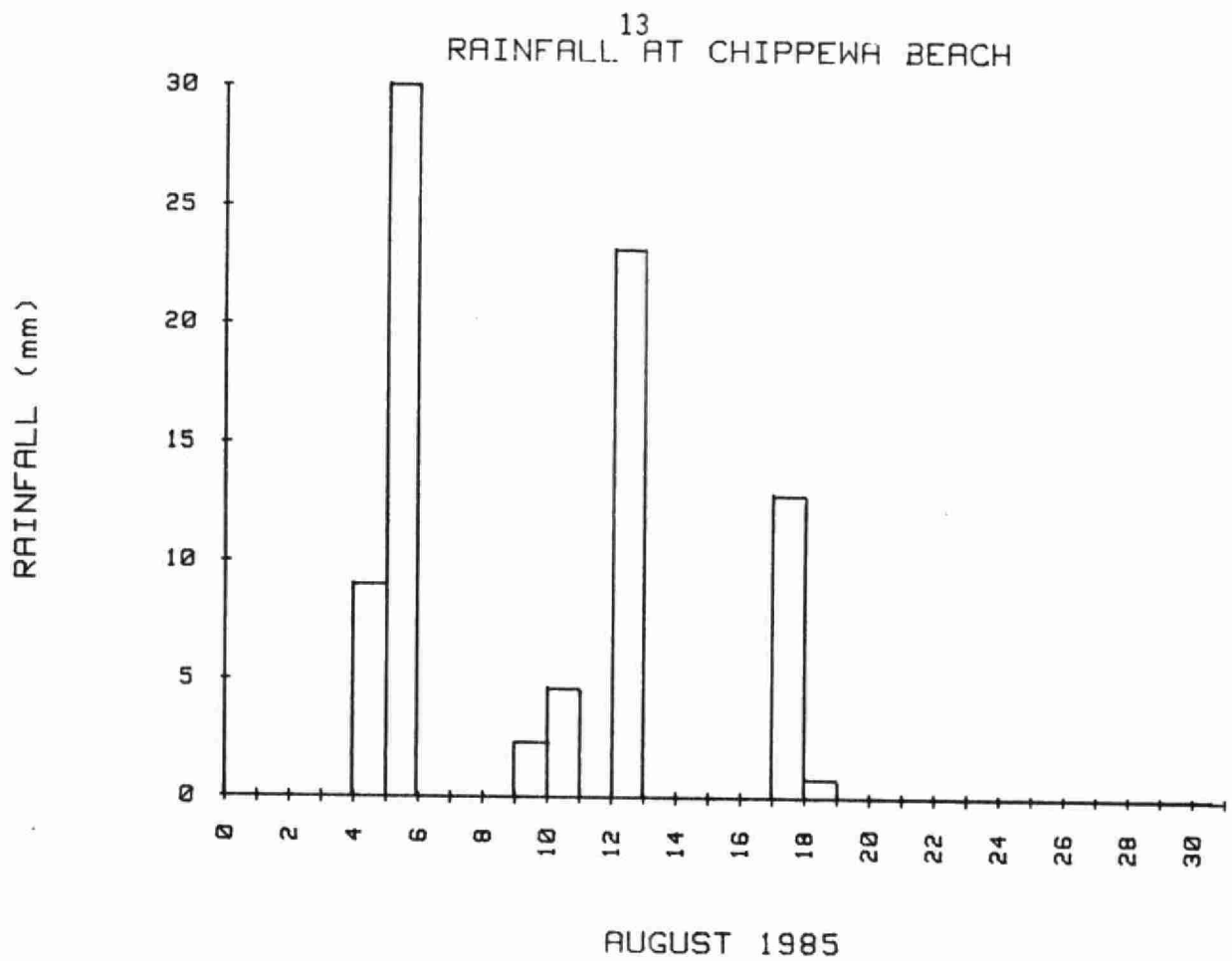


Figure 4. Rainfall and morning (A) and afternoon (P) fecal coliform geometric mean levels at Chippewa Beach, August 1 - 23, 1985.

The mechanism by which stormwater entered and contaminated the bathing area at Chippewa Beach was clearly demonstrated during a storm at Chippewa Park on the evening of August 12th, 1985. On that day, a light rain had begun to fall in the morning. By afternoon, the rain had increased in intensity until by evening, a heavy rain was falling. In addition, a steady wind blowing toward the beach, had created high waves, about one meter in height, on Lake Superior. These waves, although reduced in size because of the breakwater protecting the bathing area (Figure 2), carried into the lagoon directly onto the beach. The high waves in the lagoon stirred up the sediments to such an extent that the water in the bathing area was extremely turbid. Water from the waves washed onto the sand beach and then flowed back into the bathing area.

A number of pools of surface run-off water had accumulated on the wide, flat, sandy beach. A large pool of surface run-off water covered the area between the sand beach and the higher ground further inland. This pool was constantly being replenished by run-off from the natural watershed inland of the beach. In turn, the pool fed several streams of water flowing across the sand beach into the bathing area. By 8 p.m., when these observations were made, the streams had already carved deep stream beds into the surface of the sand. The water flowing into the bathing area from these streams was very muddy.

A bacteriological sample was collected from each of three separate streams flowing across the beach. These samples were analyzed on the same evening, within one hour of collection. The samples contained between 400,000 and 900,000 FC and 240,000 and 540,000 E. coli per 100 ml. These were the highest levels of fecal bacteria found during two years of sampling at Chippewa Beach. Nevertheless, it is probable, that had these samples been collected from the first flush of stormwater flowing into the bathing area, the bacterial levels would have been even higher.

At 9:00 a.m., on the following morning, August 13th, the rain had stopped and the sun was shining. The total rainfall recorded for the previous day was 23.1 mm. Plant material and other debris littered the beach, demonstrating the force of the storm on the previous day. The sand on the beach was deeply

scarred in a number of places from the streams of water flowing across it into the bathing area. At the water's edge, the sand was alternately either built-up or undercut due to the action of the high waves in the lagoon. One small stream of water was still flowing across the beach. A bacteriological sample collected from this stream contained 55,000 FC and 18,000 EC per 100 ml, a level not unexpectedly reduced from the previous day since the ground had been flushed by the rain for a number of hours.

Water samples collected from the bathing area on the morning of August 13th (Figure 4, peak #9) contained high levels (2400/100 ml) of fecal coliforms. The water in the bathing area was still extremely turbid, even though the lagoon was relatively calm at this time. The turbidity of the water in the bathing area was the highest observed all summer. The highly turbid water formed a plume which extended beyond the breakwater, some distance out into Lake Superior. This observation provided some evidence that the net flow of water was out of the lagoon, rather than in. Thus, it appeared unlikely that Chippewa Beach was being contaminated from pollution sources via Lake Superior as had been thought earlier.

Wave Action: The storm on August 12th was accompanied by high waves in the bathing area at Chippewa Beach. These waves had created extremely turbid water in the lagoon. The above normal turbidity levels in the bathing area persisted for two days. The extreme turbidity of the water appeared to be caused solely by the high waves, since earlier in the summer, heavy rainfall alone had increased the turbidity of the water in the bathing area only slightly.

High waves were observed in the lagoon on only two occasions during the period of this study, August 12th and 23rd, 1985. Elevated FC levels were observed both times. On the first occasion, the high waves were accompanied by heavy rainfall. Therefore, it was impossible to separate the effects of each factor. However, on August 23rd, high waves were observed without rain. The elevated FC levels on this date (Figure 4, peak #11) could be attributed only to the high waves. This observation indicated that FC levels that exceeded a geometric mean of 100

FC per 100 ml could be produced by wave action alone. High waves in the bathing area would not only stir up the underlying sediments and its accompanying load of bacteria, but also by washing on to the sand beach, would flush bacteria from the sand back into the bathing area.

Beach Grading: The storm on August 12th had caused substantial damage to Chippewa Beach. Therefore, as was common practice, within a few days of the storm, the sand beach was graded by a tractor using a blade to smooth the sand. The entire beach was graded, up to the water's edge, and even a short distance into the water. On occasion, it was observed that the grader entered the bathing area to push sand that had washed from the beach into the bathing area back onto the beach.

During the 1985 study period, Chippewa Beach was graded on five occasions: July 17th, July 25th, July 30th, August 8th, and August 13th. With the exception of August 13th (when the beach was graded after the afternoon sampling run), water samples were collected from the bathing area before and after each grading.

TABLE 3. Geometric mean fecal coliform level in the bathing area at Chippewa Beach, before and after grading of the sand beach.

SAMPLING DATE	BEFORE GRADING		AFTER GRADING	
	TIME	FC/100 ml	TIME	FC/100 ml
July 17	9.00 am	25	3.00 pm	750
July 25	9.00 am	98	3.00 pm	229
July 30	9.00 am	28	3.00 pm	980
August 8	9.00 am	86	3.00 pm	882

On July 17th, at 9.00 a.m., samples collected from the bathing area prior to any grading had an FC geometric mean of 25 per 100 ml (Table 3). Samples collected after the grading, at

3.00 p.m. on the same day, had an FC geometric mean of 750 per 100 ml (Figure 3, peak #2). On July 25th, FC levels increased from 98 to 229 per 100 ml (Figure 3, peak #4). The July 30th levels increased from 28 to 980 (Figure 3, peak #5), and the August 8th levels from 85 to 882 (Figure 4, peak #8).

Following each grading, the FC levels of the water in the bathing area increased from that observed prior to the grading. Between the morning and afternoon sampling runs, the only factor that was significantly different was the grading of the sand beach. Rainfall was insignificant, wind and wave action were relatively calm, and bather loading was no heavier than usual. These observations indicated a direct relationship between grading of the sand beach and an increase in the FC levels in the bathing area. It appears that the grading in the shallow water either introduced contaminated sand from the beach into the water of the bathing area or stirred the sediments underlying the shallow water sufficiently to reintroduce bacteria from these sediments into the water. In 1984, the sand was observed to be graded only once. However, since samples were collected only once per day, no appreciable effect on the FC levels were noted at that time.

Bather Load: The day-camp bathers provided the potential for an additional bacterial source that was not present during the 1984 study. By the time that the MOE sampling program was initiated in 1985, a buoyed enclosure had already been established toward one end of Chippewa Beach for the day camp program (Figure 2). Over the summer, the size of this enclosure changed slightly, but generally, it measured 20-30 m wide and 15-20 m deep. This enclosure was the designated area for all bathing activities by the children in the day-camp program. Bathing by the general public was concentrated along Chippewa Beach to the right of the enclosure.

At Hazelwood Beach in 1984, the prime bacterial indicator of bather loading was P.aeruginosa. This organism was found at substantially higher levels in samples collected during the afternoon sampling runs when bathers were present than in the

morning runs prior to any bathing activity. However, in 1985 at Chippewa Beach, there were no significant differences in either the frequency of P.aeruginosa detection or the levels detected between morning and afternoon sampling runs.

The inability to detect the contribution of bathers to the overall bacterial levels in the bathing area at Chippewa Beach in 1985 may have been a result of several factors that were different from Hazelwood Beach in 1984. At Chippewa Beach, the water quality of the bathing area was very sensitive to heavy rainfall, high waves and beach grading. These factors were either not present at Hazelwood Beach or did not cause any changes to the water quality. Each of these factors caused the bacterial levels in the bathing area at Chippewa Beach to increase dramatically. The high bacterial levels resulting from these factors may have masked differences between the morning and afternoon data caused by bather loading. In addition, the daily cycle of day-camp bathing was interrupted when Chippewa Beach was placarded and the bathing program was moved to Sandy Beach on Lake Superior. This interruption did not occur at Hazelwood Beach. Finally, the temperature of the water in the bathing area was colder at Chippewa Beach than at Hazelwood. The colder water may have prevented any proliferation of P.aeruginosa.

2. BOULEVARD LAKE PARK

BACKGROUND

There are three beaches on Boulevard Lake: Lakeview Beach, Sandy Cove Beach and Sunnyside Beach (Figure 5). In the summer of 1984, the fecal coliform daily geometric mean of samples collected from the bathing areas of these beaches were found to exceed 100 per 100 ml on only one day at Lakeview Beach and Sandy Cove Beach (1). The mean fecal coliform level at Sunnyside Beach did not exceed 100 throughout the summer of 1984.

The elevated fecal coliform levels at Lakeview Beach and Sandy Cove Beach were a result of stormwater run-off entering the bathing area following a heavy rainfall. However, the exact duration of this 'pollution event' was not known since these beaches were monitored only twice per week during 1984.

METHODS

The 1985 survey at Boulevard Lake was designed to determine the persistence of the fecal bacteria following a 'pollution' event, and a more complete study of the fluctuations in water quality of the outfalls flowing into Boulevard Lake as a result of rainfall. In addition, the 1985 study continued the monitoring of P.aeruginosa in the bathing area of the three beaches as recommended in the 1984 report (1).

Sampling Stations: The locations of the beach and off-beach sampling stations used in 1985 at Boulevard Lake Park were identical to 1984. Beach stations LVB-1, 2, 3, SCB-1, 2, SSB-1, 2, and 3, were established at Lakeview Beach, Sandy Cove Beach, and Sunnyside Beach, respectively.

Sampling Frequency: All beach and off-beach stations were sampled once each weekday between 11:30 a.m. and 1:30 p.m. No samples were collected on the weekend or on holidays.

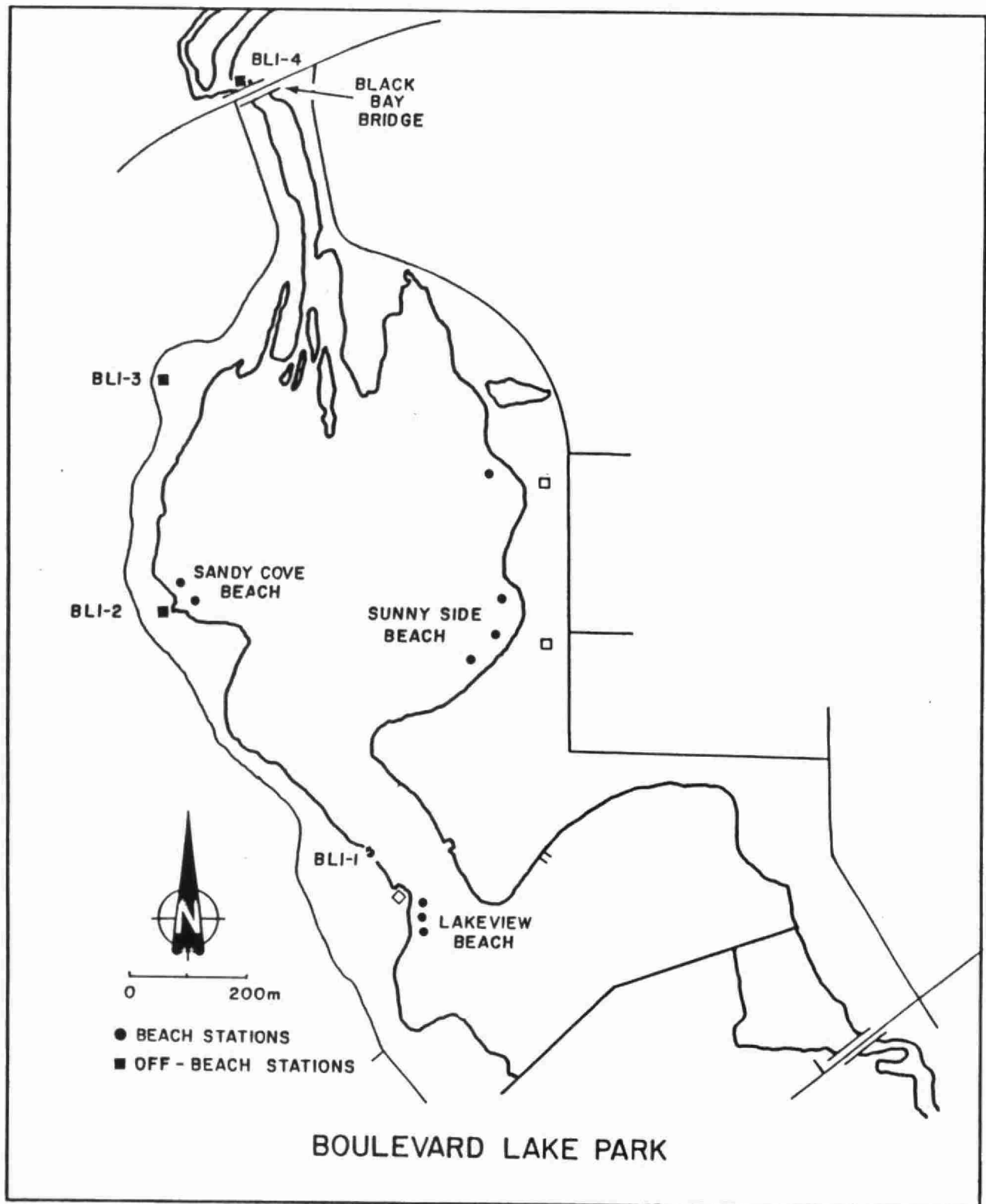


Figure 5. Locations of beach and off-beach sampling stations at Boulevard Lake Park.

Rainfall Monitoring: A rainfall collector was set up approximately 1 km from Boulevard Lake Park, in the yard of an MOE staff member. Rainfall measurements were made each day (including weekends and holidays) prior to each sampling run.

RESULTS AND DISCUSSION

Water sampling at Lakeview Beach, Sandy Cove Beach and Sunnyside Beach was initiated on July 9th, 1985, and continued until August 19th, 1985. Twenty-nine sampling runs were completed. No significant differences in the bacterial data were found between stations in the same bathing area.

It was found that the fecal coliform daily geometric mean level of the bathing area samples exceeded 100 FC per 100 ml on four days at Lakeview Beach, two days at Sandy Cove Beach and three days at Sunnyside Beach (Underlined values in Table 4).

As in 1984, it was found that there was a direct relationship between heavy rains that produced stormwater run-off and bathing area water quality that exceeded a geometric mean of 100 FC per 100 ml. Between July 9th and July 31st, 1985, a quantity of rain greater than 10 mm occurred twice (Figure 6). However, while both of these events produced slight increases in the fecal coliform geometric mean level at the three beaches, neither produced sufficient stormwater run-off to cause the fecal coliform level in the bathing area to exceed a mean of 100.

Between August 1st and August 19th, rainfall greater than 10 mm occurred four times (Figure 7). Water samples were collected on the day after the rainfall for only two of those events: August 6th and August 13th. On both occasions, the quantity of rain falling in the previous 24 hours was close to 20 mm. Following these heavy rains, the fecal coliform geometric mean of the bathing area samples collected at the three beaches exceeded 100.

At Lakeview Beach, the fecal coliform level was above a mean of 100 per 100 ml for 48 hours following the two heaviest rains in August. However, at Sandy Cove Beach, the mean fecal coliform level fell below 100 within 24 hours of these rains. Twenty-four to forty-eight hours were required at Sunnyside Beach.

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RAINFALL AT BOULEVARD LAKE

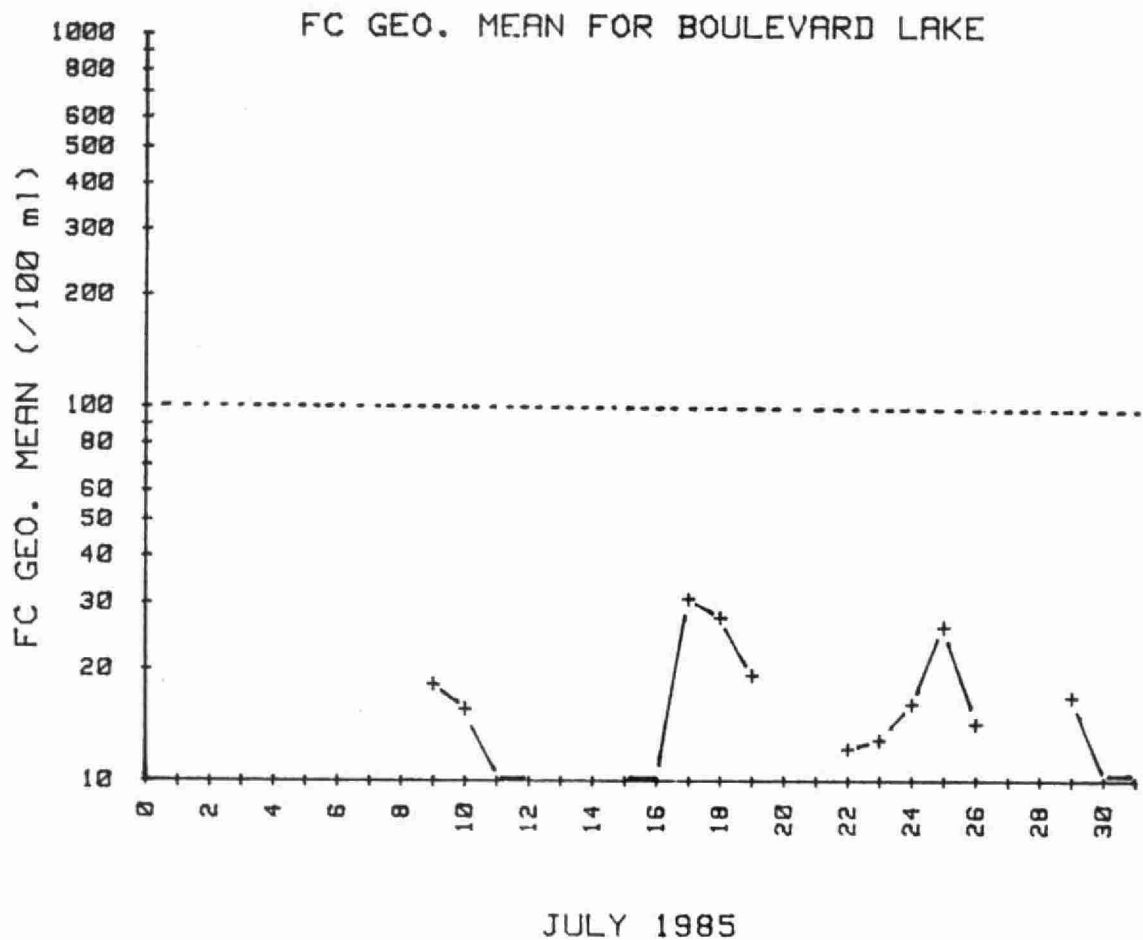
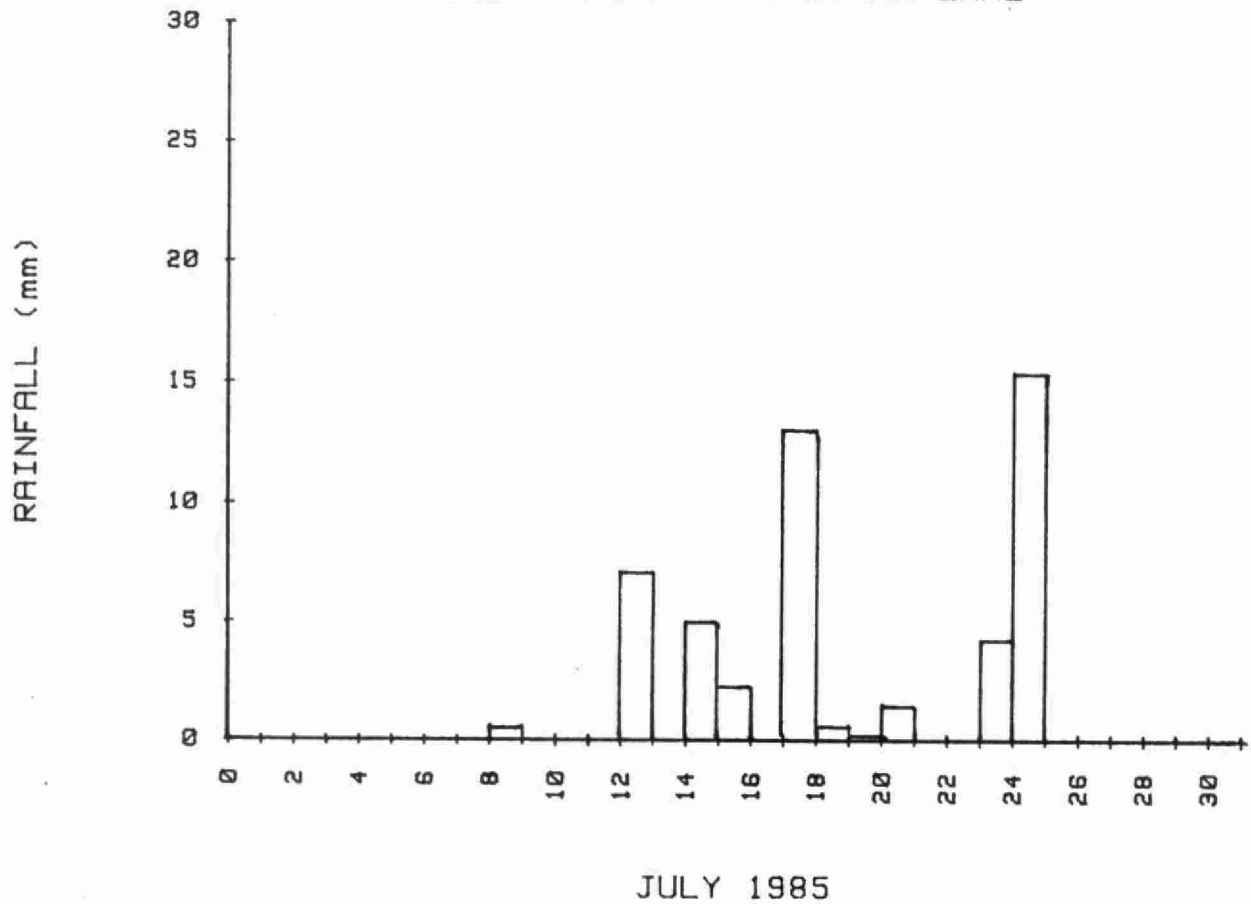
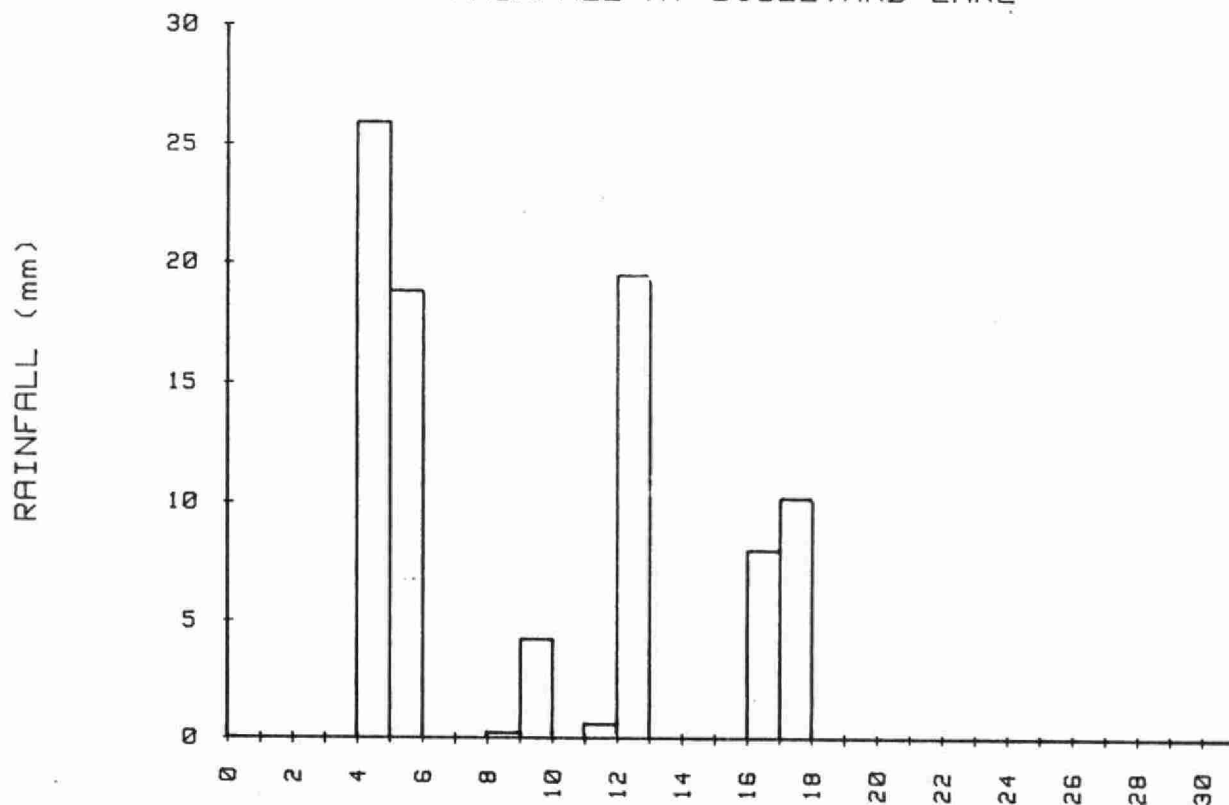
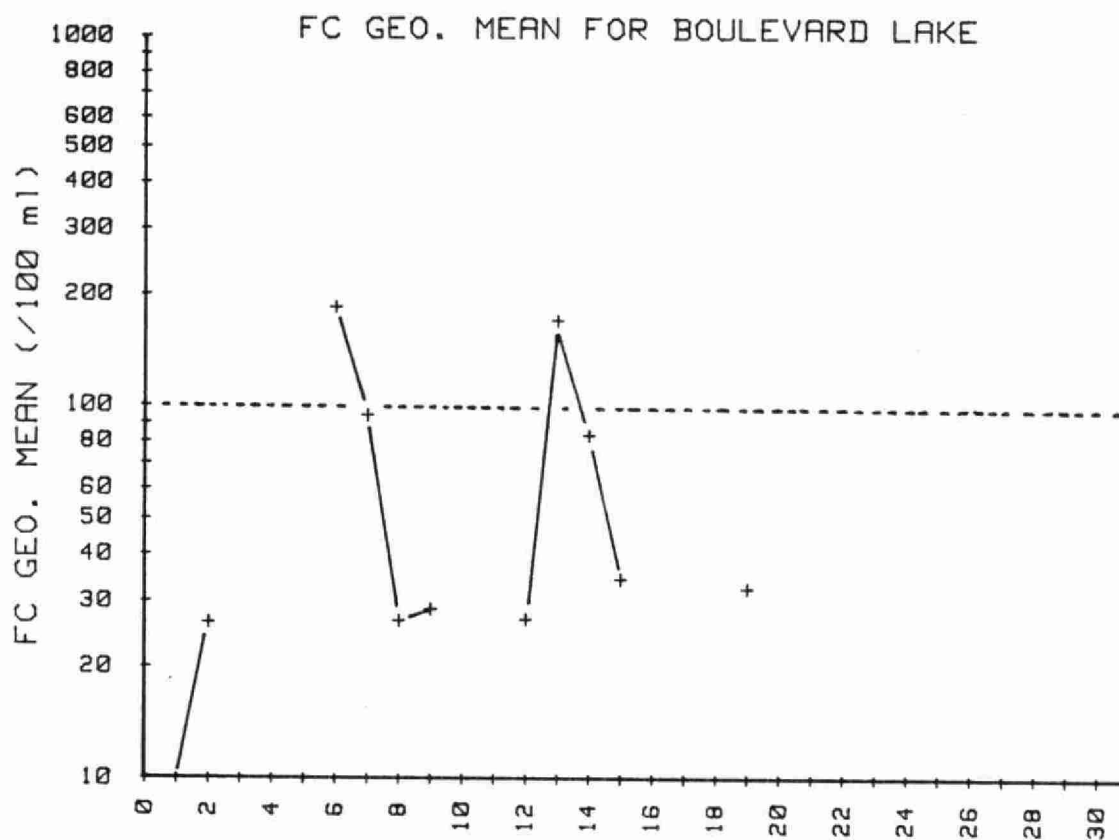


Figure 6. Rainfall and fecal coliform geometric mean levels (combined beach station data) at Boulevard Lake, Boulevard Lake Park, July 9 to July 31, 1985.

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RAINFALL AT BOULEVARD LAKE



AUGUST 1985



AUGUST 1985

Figure 7. Rainfall and fecal coliform geometric mean levels (combined beach station data) at Boulevard Lake, Boulevard Lake Park, August 1 to August 19, 1985.

TABLE 4. Fecal coliform daily geometric mean levels at the Boulevard Lake Park beaches, July 9 to August 19, 1985.

SAMPLING DATE YY MM DD	FECAL COLIFORM DAILY GEOMETRIC MEANS PER 100 ML		
	LAKEVIEW BEACH	SANDY COVE BEACH	SUNNYSIDE BEACH
85 7 9	20.0	7.1	31.1
85 7 10	14.4	14.1	18.2
85 7 11	7.9	10.0	10.0
85 7 12	7.9	5.0	9.1
85 7 13			
85 7 14			
85 7 15	6.3	7.1	14.4
85 7 16	7.9	7.1	10.0
85 7 17	52.4	14.1	30.4
85 7 18	20.0	49.0	25.5
85 7 19	14.4	12.2	34.8
85 7 20			
85 7 21			
85 7 22	7.9	15.8	15.9
85 7 23	15.9	7.1	15.9
85 7 24	9.1	17.3	27.1
85 7 25	55.2	24.5	12.6
85 7 26	12.6	24.5	11.4
85 7 27			
85 7 28			
85 7 29	15.9	20.0	15.9
85 7 30	3.4	4.9	8.0
85 7 31	5.8	2.8	5.0
85 8 1	6.3	4.0	14.7
85 8 2	72.7	5.0	28.8
85 8 3			
85 8 4			
85 8 5			
85 8 6	189.6	196.3	172.5
85 8 7	120.4	57.1	102.3
85 8 8	26.6	21.2	31.1
85 8 9	21.8	21.9	44.7
85 8 10			
85 8 11			
85 8 12	24.9	28.3	28.2
85 8 13	202.0	148.9	149.0
85 8 14	123.9	57.1	71.7
85 8 15	47.3	32.5	26.2
85 8 16			
85 8 17			
85 8 18			
85 8 19	27.5	42.3	32.6
Seasonal Mean	21.4	17.3	23.8

The shorter persistence of the high bacterial levels at Sandy Cove Beach may reflect a better circulation of water from the Current River.

In 1985, it was found that the quantity of rain required to produce a 'pollution' event at the beaches at Boulevard Lake was approximately 20 mm. This was less than that observed in 1984 at Boulevard Lake Park, but substantially more than that required at Chippewa Beach.

One hundred and forty-four bathing area samples were analyzed for P.aeruginosa at Boulevard Lake in 1985. This organism was present in 31% and 64% of the beach samples analyzed in July and August, respectively. The frequency of isolation of P.aeruginosa was lower at each beach in 1985 than in 1984. P.aeruginosa was present in 76%, 50%, and 60% of the samples analyzed in August at Lakeview Beach, Sandy Cove Beach and Sunnyside Beach, respectively. The highest level found at any Boulevard Lake beach station throughout the summer was 18 per 100 ml. Except for August 7th and August 9th, almost all isolations of P.aeruginosa were below 10 per 100 ml. The causes of the higher levels of P.aeruginosa on those two dates are unknown.

Four inputs to Boulevard Lake were monitored in 1985: three outfalls (station BLI-1, 2 and 3) and the Current River (BLI-4). Sampling station BLI-1 was a 36" cement storm sewer which emptied into Boulevard Lake just north of Lakeview Beach (Figure 5). This outfall drained the area around the Lakehead Psychiatric Hospital. As expected of a storm sewer, this outfall had a highly variable flow rate. During several sampling runs, there was evidence that high flows had occurred between sampling runs. The high flows at this station were generally associated with higher bacterial levels. Unfortunately, when samples were not available from these high flows, the full extent of the bacterial levels entering Boulevard Lake was unknown. The levels of fecal bacteria in the other two outfalls, BLI-2 and BLI-3, fluctuated to a limited degree, usually in response to heavy rainfall. The highest level of fecal coliforms found at these outfalls in 1985 were 270 and 1400 per 100 ml, respectively. The levels of fecal coliforms in the Current River did not exceed 100 per

100 ml throughout the summer.

3. HAZELWOOD CONSERVATION AREA

BACKGROUND

In 1984, the fecal coliform daily geometric mean of samples collected from the bathing area at Hazelwood Beach was found to exceed 100 per 100 ml on three days during the summer. These elevated fecal coliform levels occurred only during the afternoon sampling runs, not during the morning sampling runs. The elevated bacterial levels were directly attributed to high bather loading at this beach (1).

The day-camp program, which had used Hazelwood Beach in the summer of 1984, returned to Chippewa Beach in 1985. Thus, the bather load at Hazelwood Beach was substantially reduced in 1985. The 1985 survey at Hazelwood Beach provided a control on the effects of bather loading against which the 1984 data could be compared.

METHODS

Sampling Stations: Three beach sampling stations were used during the summer of 1985. The location of these three stations corresponded closely to the locations used in 1984. No off-beach stations were established.

Sampling Frequency: Samples were collected once per week, on a weekday afternoon by Lakehead Region Conservation Authority staff. No samples were collected on the weekends or on holidays.

Rainfall Monitoring: Stormwater run-off did not affect the bacteriological water quality of the bathing area at Hazelwood Beach in 1984. Therefore, no on-site rainfall monitoring was used at Hazelwood Beach during the summer of 1985.

RESULTS AND DISCUSSION

Water sampling at Hazelwood Beach was initiated on July 3, 1985 and continued until August 27, 1985. During this period

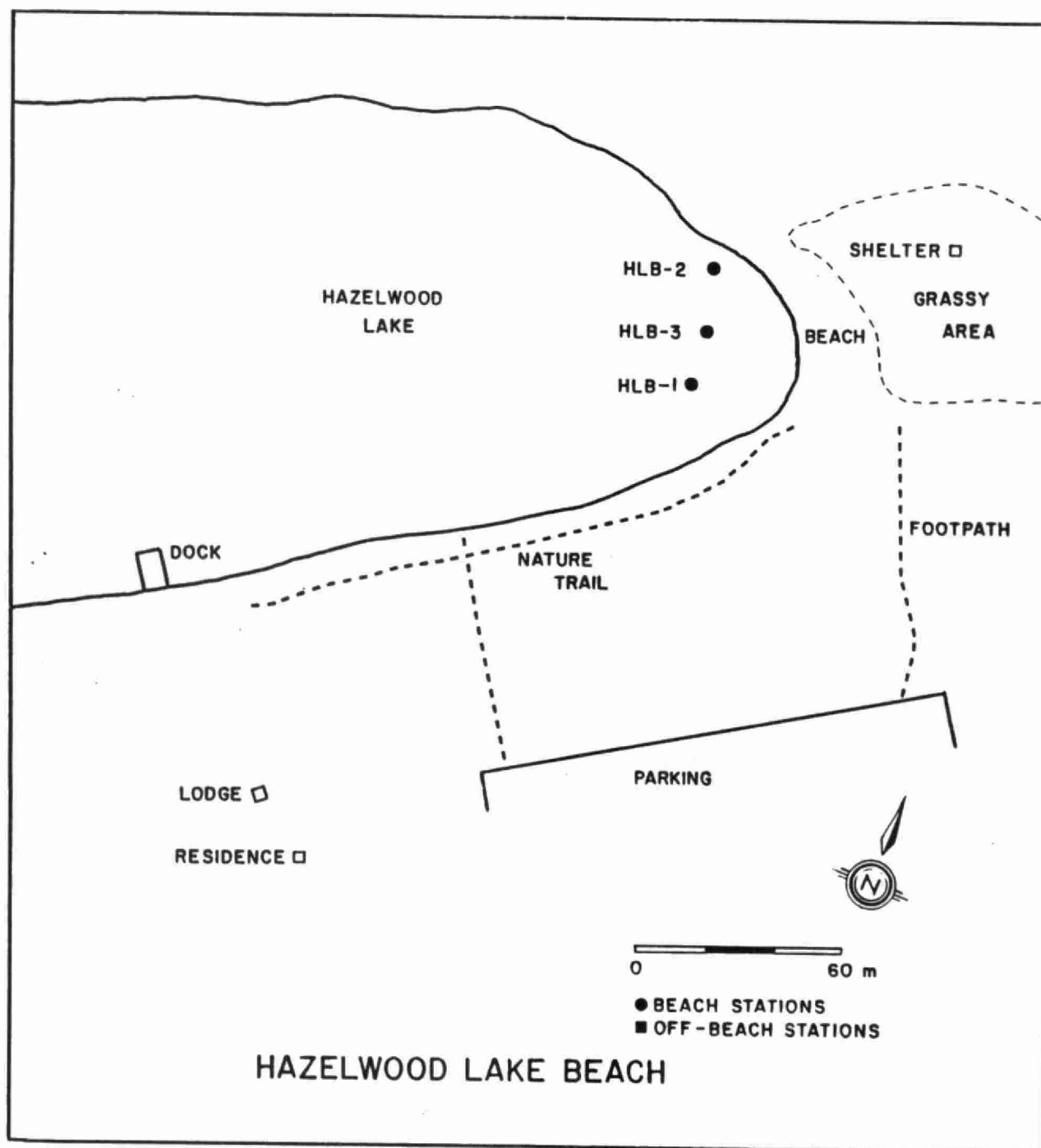


Figure 8. Locations of beach sampling stations at Hazelwood Beach, Hazelwood Lake Conservation Area.

TABLE 5. FECAL COLIFORM GEOMETRIC MEAN LEVELS IN THE BATHING AREA AT HAZELWOOD BEACH,
JULY 3 TO AUGUST 27, 1985. ALL DATA

SAMPLING		FECAL COLIFORM COUNTS PER 100 ML					DAILY GEOM. MEAN
DATE		BEACH STATION NUMBERS					
YY	MM DD	HLB1	HLB2	HLB3			
85	7 3	2:30	8	20	4		8.6
85	7 10	2:30	< 4	4	24		5.8
85	7 17	2:10	< 4	4	< 4		2.5
85	7 24	1:30	4	< 4	< 4		2.5
85	7 31	1:30	< 4	< 4	< 4		2.0
85	8 7	3:00	8	56	64		30.6
85	8 14	2:00	16	12	16		14.5
85	8 21	1:15	4	< 4	< 4		2.5
85	8 27	1:45	< 4	8	12		5.8
GEOM. MEAN		4.0	6.2	6.4			

SEASONAL GEOMETRIC MEAN: 5.43

the bacteriological water quality of the bathing area was excellent - the highest FC daily geometric mean recorded was 31 per 100 ml (Table 5).

In contrast to the high levels of P.aeruginosa found in 1984, P.aeruginosa was below detection limits during each of the nine sampling runs in 1985.

In 1985, the bather loading at Hazelwood Beach was substantially less than in 1984 due to the absence of the day-camp children. In 1984, the prime source of elevated bacterial levels in the water of the bathing area was the bathers themselves or their bathing activities. Thus, the reduced number of bathers helped to contribute to the excellent water quality observed in 1985.

GENERAL DISCUSSION AND CONCLUSIONS

During the summer of 1985, the water quality of the bathing areas of five beaches and their associated off-beach pollution sources were monitored. With the exception of Hazelwood Lake Beach, where the bacteriological water quality of the bathing area was excellent throughout the summer, Lakeview Beach, Sandy Cove Beach, Sunnyside Beach and Chippewa Beach all exceeded a fecal coliform geometric mean of 100 per 100 ml several times during the summer.

The bathing area at Chippewa Beach was placarded twice by the Medical Officer of Health. Placards were erected on the morning of July 12, 1985 and removed on the morning of July 17. Placards were again erected at Chippewa Beach on the morning of August 1, and removed in the early afternoon of August 2. Placards were not erected at any of the other local beaches studied.

The fecal coliform seasonal geometric mean at Hazelwood Beach was very low, only 5.4 per 100 ml. Lakeview Beach, Sandy Cove Beach and Sunnyside Beach had a fecal coliform seasonal geometric mean of 21.4, 17.3 and 23.8, respectively. The higher levels at the Boulevard Lake beaches were caused in part by the intermittent contamination introduced into the bathing areas by stormwater run-off. A substantially higher seasonal mean was found at Chippewa Beach (85.5 per 100 ml). This indicated the more frequent entrance of bacterial contaminants into the bathing area at this beach.

As in 1984, the majority of fecal coliform bacteria recovered from either the beach or off-beach stations, were E.coli. This organism accounted for 60 to 100 % of the fecal coliform population. The presence of E.coli is indicative of a fecal source.

A bather load effect was not detected at any of the beaches monitored in 1985. However, it was noted that the bather loading data recorded at the time of sampling was inadequate to describe the level of bathing activity that may have occurred at other times during that day. Unfortunately, monitoring the bather loading more closely was outside the scope of the study.

At the three Boulevard Lake beaches, only one factor was found to adversely affect the water quality of the bathing area: stormwater run-off caused by heavy rainfall equal to or greater than approximately 20 mm within a 24 hour period. However, at Chippewa Beach, the factors affecting the water quality of the bathing area were substantially more complex. Three factors, stormwater run-off, high waves and beach grading were found to be the primary causes of elevated fecal coliform levels in the bathing area at that beach.

At Chippewa Beach, each of these factors contained one common element: sand introduced from the beach into the water of the bathing area or sediment in the bathing area stirred up into the water. It appeared that the beach sand and sediment contained substantial levels of fecal bacteria. The fecal bacteria were probably deposited onto the sand and sediment by ducks and gulls or other birds and animals.

On several occasions, a small flock of ducks was observed in the lagoon at Chippewa Beach and, on one occasion, even inside the enclosure used by the day-camp children. Gulls were regularly observed at the beach, although not in great numbers at any time. The ducks and gulls seemed to prefer to use the beach near stations CB-1 and CB-2. This may explain the slightly higher fecal coliform geometric means found at the sampling stations toward that end of the beach. Feces from birds were observed not only on the sand beach in that general area but also lying in the shallow water of the bathing area. Dogs were also observed on the beach sand from time to time during the summer.

Feces from ducks and gulls contain high levels (10^8 per gram) of fecal coliforms and E.coli and low levels of P.aeruginosa, Salmonella and Campylobacter (Personal communication, unpublished data, E. Harris, Microbiol. Dept., Univ. of Toronto). The ratios of fecal coliforms, E.coli and P.aeruginosa found at Chippewa Beach were consistent with the ratios in the feces of these birds. Fecal coliform and E.coli levels were always substantially higher than P.aeruginosa in the water of the bathing area. Given an output of approximately 10^{10} fecal bacteria per day and the right conditions necessary to spread this material (such as high waves), a single duck potentially could contaminate a tremendous quantity of water.

Fortunately, fecal bacteria introduced into the water column tend to either die off or settle into the sediments fairly quickly. At Chippewa Beach, it was observed that elevated levels of fecal bacteria were substantially reduced within 24 hours of their introduction or resuspension into the water column. However, once introduced into sand or sediment, fecal bacteria may survive for days or even weeks (Personal communication, G. Palmateer, MOE, London, Ontario). The levels of fecal coliform bacteria and E.coli in the sand or sediment at Chippewa Beach were never enumerated. However, had this been done, it is probable that high numbers of these organisms would have been found. A reservoir of bacteria would thus be available in the sand and sediment from which the water column could be contaminated by any factor that resuspended the sand or sediment into the water. At Chippewa Beach, the high waves and beach grading appeared to simply resuspend this reservoir of bacteria into the water column producing elevated levels of fecal bacteria in the bathing area.

Elimination of the intermittent bacterial contamination of the bathing area at Chippewa Beach appears rather difficult to correct. It may be possible to prevent some of the stormwater run-off from directly entering the bathing area by redirecting some flows. However, the majority of the run-off would probably still reach the lagoon, since it is the lowest point in that small watershed. In addition, it appears virtually impossible to prevent birds and other animals from using the beach. Therefore, it is expected that the intermittent fecal contamination of the bathing area at Chippewa Beach will continue in the future.

GENERAL RECOMMENDATIONS

1. Attempts should be made to prevent gulls, and especially ducks and other animals from using the beach and bathing area at Chippewa Beach. All garbage containers on the beach should be totally enclosed to prevent attracting gulls.
2. The feasibility of redirecting some of the stormwater run-off so that it does not enter the bathing area at Chippewa Beach should be examined.
3. When necessary, grading of the sand beach at Chippewa Beach should be completed as soon as possible following damage caused by heavy rain or high waves. Immediate grading will combine the effects of these factors into a single 'pollution' event. Beach grading at a later time will cause elevated FC levels in the bathing area for an additional period of time.
4. At those beaches where the impact of physical factors such as heavy rainfall or high waves on the water quality of the bathing area are known, the physical factors themselves could be used in place of laboratory results to provide an indication of the water quality in the bathing area so that immediate action could be taken.
5. If physical factors are used as suggested above, an on-site rainfall collector is recommended.

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ACKNOWLEDGEMENTS

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